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Magnolia acuminata

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Arboretum Activities

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On Thursday, November 16, the Director gave an illustrated talk to the Philadelphia Botanical Club with the title "Glimpses of Florida and the West Indies." On December 6 he spoke at an evening meeting of The Faculty Club of the University; the subject of this lecture was "The Four Seasons at the Morris Arboretum."

Dr. Li writes from Berkeley, California, where he is spending six months on a Guggenheim grant, to say that his studies on the woody plants of Formosa are progressing well and that he is delighted with the rich resources of the herbarium at the University of California. On November 16 Dr. Li addressed the California Botanical Society on the topic of, "The Morris Arboretum and its Collection of Woody Plants."

Dr. Allison attended the annual meetings of the American Phytopathological Society which were held in Biloxi, Mississippi, from December 10 to 13.

We announce with regret the resignation, on November 30, of Miss Mary O. Milton who had been propagator on the Arboretum staff for more than five years. Miss Milton left in order to accept the position of Horticulturist at the Pennsylvania Horticultural Society.

(Continued on Page 70)

The Temperate American Magnolias

JOHN M. FOGG, JR.

Few trees hardy in northern climes can surpass the Magnolias in the size and beauty of their flowers. While it is true that the American species, in which the blooms are produced with or following the unfolding of the leaves, are somewhat less spectacular than those from Asia, in most of which the flowers precede the appearance of the foliage, nevertheless our native forms possess a distinction and charm which entitle them to a place in any collection of trees. One of them, *Magnolia grandiflora*, is probably as widely cultivated as any ornamental tree in the Northern Hemisphere.

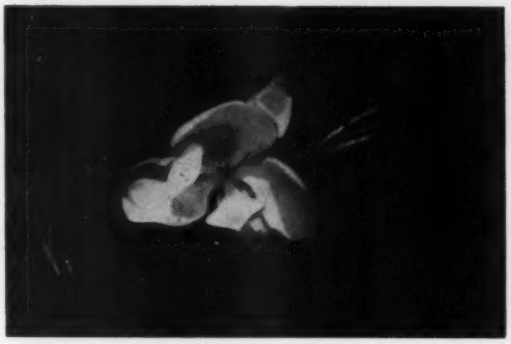

Fig. 35. *M. grandiflora*

THE MAGNOLIA FAMILY

The limits of the Magnoliaceae have varied over the years in conformity with the views of different authorities. According to earlier interpretations, the family contained about a dozen genera, including *Illicium, Schisandra, Tetracentron, Trochodendron, Kadsura* and *Drimys*. The present tendency, following Hutchinson (1926), Dandy (1927), and others, is to restrict it to *Magnolia, Liriodendron, Manglietia, Michelia* and *Talauma*. Of these only the first two occur in temperate North America.

It is worthy of note that many botanists regard the Magnoliaceae as one of the most primitive of all families of Angiosperms. In support of this view may be cited the woody habit, the simple leaves, the unspecialized character of the floral parts, and the numerous, free, spirally arranged stamens and carpels.

The discontinuous distribution of most modern representatives of the family is also an indication of antiquity, and parallels that of other groups of Dicotyledons which are likewise considered to be both primitive and ancient.

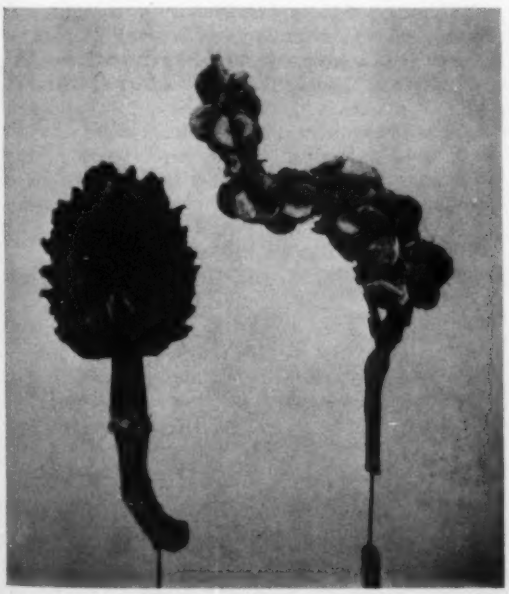

Fig. 34. Fruits of *M. macrophylla* and M. × *Soulangiana*

THE GENUS MAGNOLIA

Magnolia was first described by the great Swedish botanist, Linnaeus, who named it in honor of Pierre Magnol, Director of the Botanical Garden at Montpellier.

In the first edition of Linnaeus's Species Plantarum, published in 1753, only a single species, namely, *M. virginiana*, is recognized, although the author, by the use of Greek letters, designates five varieties. In later works Linnaeus described *M. acuminata, M. grandiflora* and *M. tripetala*, all of them from North America.

At the present time the genus is generally regarded as embracing some seventy species. Of these nine are native to the Eastern United States, eight occur in Mexico and Central America, eight are indigenous to the West Indies, one is found in northern South America, and the re-

Fig. 36. *M. virginiana*

mainder (about 45) are Oriental, growing in a triangular area which extends from Japan across China to the eastern Himalayas and south to Java. (Dandy, 1950)

All Magnolias are trees or in a few cases shrubs, e.g. the Chinese *M. liliflora*. Most species are deciduous, but a few like *M. grandiflora* and *M. Delavayi*, retain their foliage throughout the year. The leaves are alternate, simple, often large and frequently interesting. Among the flowers, which are borne singly, are some of the largest and most spectacular of any group of trees found outside the tropics.

The perianth segments of Magnolias are usually in threes or multiples thereof. In those species in which the calyx is distinct from the corolla the number of sepals is generally three and the petals may number three, six, nine or even more. In other species, however, there is no clear difference in shape or color between sepals and petals and it is for this reason that the term "tepal" is frequently applied to the accessory organs of the flower.

The fruit is a cone-like structure formed of the numerous accrescent carpels. It is often large and showy, lending interest to the tree in late summer or autumn. The seeds which in most species are bright red are released when the carpels split open and usually remain attached by slender threads.

Classification

Of the several systems of classification which have been proposed for *Magnolia*, the one most widely accepted in this country is that of Rehder in his Manual of Cultivated Trees and Shrubs. According to this arrangement, the genus is divided into two subgenera: Magnoliastrum and Gwillimia.

In the first of these subgenera the flowers appear after the leaves, the fruiting body is symmetrical and somewhat cylindrical or globose, and the carpels are more or less distinctly beaked. The second subgenus is characterized by precocious flowers, unsymmetrical and somewhat twisted fruits and carpels which are not, or only rarely, beaked. Figure 34 clearly shows these two types of fruits as exemplified by *M. macrophylla* and *M.* × *Soulangiana*. All nine of the temperate American species belong to the first of these groups, the sub-genus Magnoliastrum.

Dandy (1950) also divides Magnolia into two subgenera, but places primary emphasis upon the manner of dehiscence of the anthers. In the subgenus Magnolia, as defined by him, the anthers open introrsely, i.e. toward the center of the flowers, while in the sub-genus Pleurochasma, they split laterally or sublaterally. Each subgenus is further divided into sections, a total of eleven being recognized. According to this arrangement two American species, *M. acuminata* and the closely related *M. cordata*, belong to the second subgenus, together with the precociously-flowering Asiatic *M. liliflora*. Small, following Spach, places these the two former species in the genus *Tulipastrum*, a division which Dandy reduces to the status of a section.

Cytologically the genus is extremely interesting. The haploid chromosome number is 19 and most species are diploid with a count of 38. However, *M. acuminata* is a tetraploid with 76, and *M. grandiflora* is a hexaploid with 114.

American Magnolias

The range of the genus *Magnolia* in temperate North America extends from central Florida to eastern Texas and Arkansas, north to New Jersey, western New York and southern Ontario. One species, *M. virginiana*, has a local outpost in eastern Massachusetts. All but one (*M. Ashei*) were described prior to the early years of the nineteenth century and all nine of them have found their way into horticulture in this coun-

Fig. 37. *M. macrophylla*

Fig. 38. *M. macrophylla*

try. Bean records all but *M. Ashei* as in cultivation in the British Isles.

The following artificial key, which is based solely on foliar characters, may help to differentiate those *Magnolias* which are indigenous to the eastern and southeastern United States.

A. Leaves coriaceous, persistent or semi-persistent.
  B. Leaves 15-20 cm. long, brownish beneath, firm-coriaceous and always persistent *M. grandiflora*
  B. Leaves 10-15 cm. long, whitish beneath, thin-coriaceous, semipersistent *M. virginiana*

A. Leaves not coriaceous, deciduous.
  C. Leaves auricled or heart-shaped at the base.
    D. Leaves glaucous beneath; more or less evenly spaced along the branches.
      E. Leaf-blades 5-8 dm. long, pubescent beneath ..... *M. macrophylla*
      E. Leaf-blades 4-6 dm. long, sparingly pubescent beneath ..... *M. Ashei*
    D. Leaves pale green but not glaucous beneath, conspicuously clustered toward the tips of the branches.
      F. Leaves elongate-obovate, gradually pointed at the apex ..... *M. Fraseri*
      F. Leaves rhombic-obovate, abruptly acute at the apex ... *M. pyramidata*
  C. Leaves not auricled or heart-shaped at the base.
    G. Leaf-blades obovate to oblanceolate, 3-6 dm. long ..... *M. tripetala*
    G. Leaf-blades elliptic to ovate or oval, 1-3 dm. long.
      H. Leaf-blades elliptic to ovate, acuminate at apex, 1.5-3 dm. long *M. acuminata*
      H. Leaf-blades oval or orbicular-oval, rounded at apex, 1-1.5 dm. long *M. cordata*

M. GRANDIFLORA L. (*M. foetida* (L.) Sarg.) Bull Bay, Loblolly Magnolia.

This is a tree of noble proportions, capable of achieving a height of some 30 m. (about 100 ft.). The coriaceous, oblong or elliptic leaves are 15 to 25 cm. (6 to 10 ins.) long, lustrous on the upper surface and usually brownish-pubescent beneath. The creamy, white, fragrant flowers are from 15 to 20 cm. (6 to 8 ins.) across. (Fig. 35). Here at the Arboretum the first flowers usually appear during the last week of June and the tree continues to bloom during the entire month of July and even into the first week of August. Few trees hardy in our area enjoy such a protracted period of blooming.

The natural range of this species is from Central Florida to Texas and Arkansas, thence north to North Carolina. Fortunately for many of us, it is hardy as far north as Philadelphia and even New York, although north of Washington it seems to require a somewhat protected situation.

Since *M. grandiflora* is almost the only tree with evergreen leaves and handsome flowers which can be grown throughout warm to cool temperate regions, it has in a period of more

Fig. 39. *M. Ashei*

Fig. 40. *M. Fraseri*

than two centuries achieved a truly world-wide popularity. According to Dandy, it was introduced into Europe as early as 1732. Today it is found in practically every garden in the British Isles and western Europe, including, of course, the Mediterranean area. Some of the largest specimens I have ever seen in cultivation are in one of the world's oldest botanical gardens, namely, that at Padova, Italy. Equally fine ones are growing in the Botanical Garden at Pisa. In such remote countries as India and Japan our American Bull Bay is highly valued as an ornamental and in the latter country in particular it is widely planted along the shores of ponds and streams in gardens and public parks.

Everyone who has observed *M. grandiflora* growing either in the wild state or in cultivation is aware of its tremendous capacity for variation. This is reflected in the habit of the plant, the shape, size, color and pubescence of the leaves and the character of the flowers. Some of these variations were first recognized in native populations, such as Pursh's var. *elliptica* and var. *obovata*, which were based on leaf shape. These may be regarded as botanical varieties. Many more have been detected and described from plants in cultivation and are known as cultivars[1]. Most of the early cultivars of *M. grandiflora* were identified in England and Europe. In recent years American growers have recognized an increasing number of individuals as worthy of description.

As noted in a previous issue of this Bulletin, I have accepted the assignment of registering all cultivar names in Magnolia[2]. To date I have recorded over 30 such names in *M. grandiflora* alone. A discussion of these will appear in a future publication.

[1] For a discussion of the distinction between cultivar and variety see Fogg. Morris Arb. Bull. 12:7. 1961.

[2] See Fogg. International Registration of Plant Names. Morris Arb. Bull. 12:17. 1961.

M. VIRGINIANA L. (*M. glauca L.*) Swamp Magnolia, Sweet Bay

A small to medium-sized tree said to attain a height of 20 m. (more than 60 ft.) but usually lower. The subcoriaceous, oval to broadly lanceolate leaves, which average 10 to 15 cm. (about 4 to 6 ins.) in length, are dark green above and whitish beneath. When young the under leaf surfaces may be silky-pubescent, but as the season progresses they tend to become entirely smooth, although retaining their glaucous hue.

The white, fragrant, subglobose flowers which are about 5 to 7 cm. (2 to 2½ ins.) in diameter appear in this area toward the end of May and continue to open for the next three or four weeks. The bright red fruits and scarlet seeds produce a brilliant effect against the lustrous foliage in late August. (Fig. 36)

The Swamp Magnolia extends from Florida and Mississippi north to Pennsylvania, New Jersey, and locally to eastern Massachusetts. A more southerly form, known as var. *australis* Sarg., is taller (up to 30 m.) and possesses more pubescent branches and foliage. There is a tendency in some quarters to apply this varietal name to any individual in which the leaves are persistent, but this characteristic was not embodied in Sargent's description. The evergreen form is more appropriately known as var. *sempervirens*, a name which has been in use since the early years of the nineteenth century.

M. virginiana is an extremely useful species. Although primarily a plant of low, wet woodlands, it flourishes in a wide variety of situations. It is attractive at all seasons of the year and well deserves the popularity which it has achieved in this country and abroad. It was the first Magnolia in cultivation in Europe, having been introduced in 1688, and has ever since been a universal favorite.

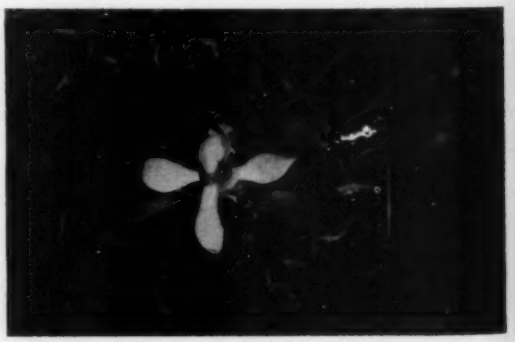

Fig. 41. *M. Fraseri*

Fig. 42. *M. pyramidata*

M. MACROPHYLLA Michx. Great-leaved Magnolia, Large-leaved Cucumber Tree.

Although this Magnolia conveys the impression of massive size it is seldom more than 16 m. (about 50 ft.) tall and most individuals in our area are appreciably smaller. The sense of bigness derives in large measure from the huge leaves, which have the largest simple blade of any tree in temperate North America. Leaves 8 dm. (about 30 ins.) in length are not unusual in the wild, although specimens cultivated in the north tend to be somewhat smaller, seldom exceeding 6 dm. (about 24 ins.). The leaves are whitish and finely pubescent beneath, with a prominently auricled base. (Fig. 37)

The flowers of this species parallel the leaves in size and are the largest of any Magnolia hardy in our area, frequently achieving a diameter, when fully open, of 2 to 3 dm. (8 to 12 ins.). The petals are six in number and the three inner ones are blotched with purple at the base. (Fig. 38). The fruit is an attractive rose-colored, globose, cone-like structure. (Fig. 37)

M. macrophylla was first described by the elder Michaux from North Carolina and is today known from that state to western Florida, west to Louisiana and north to Kentucky. It is, however, hardy as far north as eastern Massachusetts. Several fine specimens may be seen here at the Arboretum as well as elsewhere in the Philadelphia area. The species is worthy of a place in any garden which can afford it ample space in which to develop and be appreciated.

M. ASHEI Weatherby.

This is a newcomer to the ranks of temperate American Magnolias, having been described by Mr. C. A. Weatherby from western Florida in 1926. The species is closely related to *M. macrophylla,* which it resembles in its auriculate-based leaves, which are whitish on the under surface. However, the leaves of *M. Ashei* are somewhat smaller and, when mature, are less pubescent on the lower surface. There appears to be some discrepancy concerning the size of the flowers. Weatherby and Small both state that they are larger than those of *M. macrophylla;* Coker and Totten say that they are much smaller. Most authorities agree that the fruiting body of *M. macrophylla* is globose whereas that *M. Ashei* is cylindrical. There are also differences in the size of the seeds.

Although this species is best known from western Florida, it grows well in our area and is hardy as far north as New York. Magnificent specimens are in cultivation in the gardens of the Henry Foundation at Gladwyne, Pa. (Fig. 39). Despite the fact that it is said to be a smaller tree than *M. macrophylla,* the plants at Gladwyne bid fair to rival that species in size.

MAGNOLIA FRASERI Walt. (*M. auriculata* Lam.) Ear-leaved Umbrella Tree.

This and the following species have leaves which are auriculate at the base and so closely clustered at the ends of the branches as to appear whorled or verticillate. (Fig. 40). *M. tripetala* also has its leaves arranged in this manner, but the leaf in that species tapers gradually toward the base.

M. Fraseri is a slender tree up to 15 m. (about 50 ft.), which grows in swamps and bottomlands from Georgia and Alabama north to West Virginia and Virginia. The obovate-spatulate leaves are gradually pointed at the apex, pale green and glabrous beneath, and from 2 to 5 dm. (8 to 20 ins.) long. The creamy white and very fragrant flowers are about 2 to 2.5 dm. (8 to 10 ins.) across. (Fig. 41). In our area they open usually during the first week in May.

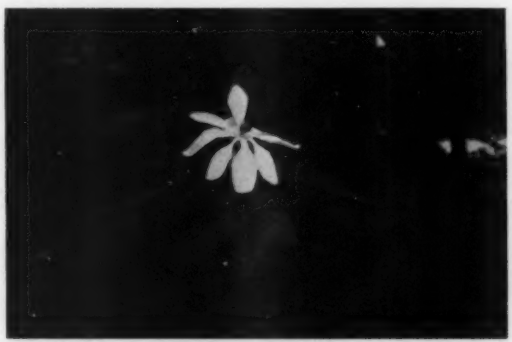

Fig. 43. *M. tripetala*

This species flourishes well in the Philadelphia region and is hardy as far north as Massachusetts. The two illustrations reproduced here were made from a fine specimen growing at the Barnes Arboretum in Merion, Pa.

M. PYRAMIDATA Bart. Bartram Magnolia.

Closely related to the preceding, this is a somewhat smaller tree, up to 10 m. (about 35 ft.) with a more restricted range. The leaves are rhombic-obovate and abruptly acute, rather than gradually pointed, at the apex. Moreover, the petioles are from 2 to 4 cm. (1 to 2 ins.) long, whereas those of *M. Fraseri* are appreciably longer. The flowers and fruit are also smaller than those of the foregoing species. (Fig. 42).

According to a map which Dr. Carroll E. Wood, Jr., of the Arnold Arboretum, has kindly furnished me, *M. pyramidata* occurs in southwestern Georgia, the panhandle of Florida, southern Alabama and southeastern Mississippi. A letter recently received from Dr. G. H. Ware of the Department of Botany, of the Northwestern State College of Louisiana, states that it also grows in Vernon Parish, Louisiana, as well as in southeastern Texas.

This species appears perfectly hardy in the Philadelphia area where it flowers a few days later than *M. Fraseri*. It deserves to be more widely grown than is apparently the case.

M. TRIPETALA L. (*M. Umbrella Lam.*) Umbrella Magnolia, Umbrella Tree.

This Magnolia is a small tree, seldom more than 10 m. (about 35 ft.), of somewhat sporadic occurrence in rich woods from Georgia to Arkansas and north to West Virginia and Pennsylvania. Its seemingly whorled leaf clusters, large white flowers and handsome pink fruits make it a conspicuous plant in the wild and a favorite subject in cultivation.

Fig. 44. *M. tripetala*

Fig. 45. *M. acuminata*

The oblong-obovate leaves are from 3 to 6 dm. (12 to 24 ins.) long, whitish and pubescent (at least when young) beneath, and gradually tapered at the base.

The chalky-white flowers which are about 2 to 2.5 dm. (8 to 10 ins.) across, exude a rather unpleasant odor. With us they usually open between the middle and the end of May (Fig. 43). The three large petal-like sepals (which give the plant its specific name) are reflexed and the six or nine petals are somewhat oblanceolate. The cylindrical fruiting bodies which are about 7 to 10 cms. (3 to 4 in.) long, begin to turn pink toward the middle of August and from then until frost are extremely ornamental. (Fig. 44).

M. tripetala is occasionally confused with the closely related Japanese *M. obovata*. In that species, however, the leaves are slightly rounded, rather than gradually tapering, at the base and the creamy white petals are spatulate.

The Umbrella Tree is a fast grower and with us exhibits something of a weedy tendency, becoming readily naturalized in moist shady situations, not only in the Arboretum but elsewhere throughout the area.

M. ACUMINATA L. Cucumber Tree.

This widely distributed species, which ranges as far north as western New York and southern Ontario, may attain a height of 30 m. (about 100 ft.). Its oblong-ovate leaves are 1.5 to 3 dm. (6 to 12 ins.) long, light green and usually slightly pubsecent beneath, and acute or short-acuminate at the apex. The campanulate to globose flower is 7 to 8 cm. (about 3 ins.) high. (Fig. 45). The three sepals are glaucous-green in color and the six petals are greenish-yellow.

The common name of this species derives from the shape and color of the young fruit which, with some exercise of the imagination, may be thought to resemble a small cucumber.

Although the flowers of this species are far from showy, the tree has great value in horticulture because of its fine proportions and good foliage. In autumn the golden-yellow color of the leaves makes it one of the most showy of all the Magnolias.

Ashe and Sargent have described varieties of *M. acuminata,* based upon differences in the size, shape, and color of the leaves. It is my own feeling that this species is no more variable than other members of the genus and distinctly less so than *M. grandiflora.*

M. CORDATA Michx.

Similar to the preceding (of which it has by some been considered only a variety), but a smaller tree, seldom over 10 m. (35 ft.), with leaves which are shorter, broader and more rounded at the apex. (Fig. 46). The leaves may also be somewhat cordate at the base, whereas those of *M. acuminata* are broadly rounded or acute.

The flowers of this plant are slightly smaller than those of *M. acuminata* and the petals are a bright canary-yellow. This species was originally discovered by the elder Michaux in the neighborhood of Augusta, Georgia, probably around 1790. It was introduced into cultivation in France soon after and all the trees growing in Europe are believed to be derived from the original introduction.

According to E. H. Wilson, this tree was lost sight of in the wild between the time of its discovery and 1926 when Mr. Louis A. Berckmans happened upon it in a dry wood some 18 miles north of Augusta.

Despite its restricted southern range, *M. cordata* is hardy as far north as the Arnold Arboretum. Since it is the only member of the genus, suitable to our climate, in which the flowers are a true yellow it merits a place in any collection of woody ornamentals.

Fig. 46. *M. cordata*

Fig. 47. *M.* × *Thompsoniana*

HYBRIDS

Although no natural hybrids have been reported *in Magnolia,* garden crosses are well known. The most familiar of these is, of course, *M.* × *Soulangiana,* an intersectional cross between two Asiatic species, *M. denudata* and *M. liliflora,* which is believed to have occurred spontaneously in the garden of the Chevalier Soulange-Bodin near Paris in or about 1820.

According to Dandy (1950), there is no example of hybridization between the two subgenera, but there are several hybrids between different sections of the same subgenus.

Among the American species the most venerable cross is the one now called *M.* × *Thompsoniana,* which is a hybrid between *M. tripetala* and *M. virginiana.* This cross, which appeared in Mr. Thompson's garden in Mile End, London, in 1808, has also been referred to as *M. major* or *M. glauca major.*

The leaves of this hybrid have the glossy upper surface of *M. virginiana,* but are appreciably larger than those of that species. The flowers, on the other hand, are larger than those of *M. virginiana* although smaller than those of *M. tripetala* (Fig. 47).

M. × *Thompsoniana* must be regarded as only semi-hardy in the Philadelphia area. Our material has been subject to severe winter injury during the last decade and a half.

We obtained scions of this cross from the Barnes Arboretum, Merion, Pa., in 1945. Shortly afterward the Barnes material was winter-killed and we were pleased to be able to supply them with rooted cuttings. In the winter of 1958-59 our material was severely damaged and we thought that once again we would be forced to seek help from Merion. One plant, however, has made a good recovery and even flowered during the summer of 1961.

Still another intersectional cross, or rather series of crosses, namely *M. grandiflora* × *virginiana*, is reported by Rehder to have originated in 1930. Although *M. virginiana* is a fairly stable species, *M. grandiflora*, as already indicated, is extremely variable. However all of the progeny known to us have the coriaceous, evergreen leaves of *M. grandiflora*.

In recent years this cross has been repeated at a number of institutions, notably the National Arboretum in Washington, and we are growing a representative series of these at the Morris Arboretum. So far none has flowered.

Magnolias at the Arboretum

All nine species and two hybrids of temperate American Magnolias are in cultivation at the Morris Arboretum. A few, like *M. macrophylla*, *M. grandiflora*, *M. virginiana*, *M. tripetala*, and *M. acuminata*, have been here for many years and are well developed, mature individuals. Most of the others have been recently acquired and have yet to give a full account of themselves.

Two separate and very diverse sites have been selected for the growing of our Magnolias. One is a low, flat protected area along Hillcrest Avenue at the foot of the Azalea Meadow. The other is an open, north-facing hill-slope along Meadowbrook Avenue south of the service entrance.

It is interesting to note that Magnolias seem to survive equally well in both situations, but that the unprotected north slope has one advantage over the more selected area: namely, the plants in the former site are somewhat retarded in their early spring development with the result that they frequently escape the deleterious effects of a sudden cold snap which would otherwise have blackened the young buds.

We are still learning much about the adjustment of these interesting plants to our local conditions and intend to try them out in a variety of other habitats.

Bibliography

Bean, W. J. Trees and Shrubs hardy in the British Isles. Ed. 7. 1951.

Coker, W. C. & H. R. Totten. Trees of the Southeastern States. 1934.

Dandy, J. E. The genera of the Magnoliaceae. Kew Bull. 1927.

———— A survey of the genus *Magnolia* together with *Manglietia* and *Michelia*. Royal Hort. Soc. Conf. Rep. 1950.

Fernald, M. L. Gray's Manual of Botany. Ed. 8. 1950.

Hutchinson, J. The Families of Flowering Plants. I. Dicotyledons. 1926.

Rehder, A. & E. H. Wilson. A Key to Magnolias. Plantae Wilsonianae. 1913.

Rehder, A. Manual of Cultivated Trees and Shrubs. Ed. 2. 1940.

Sargent, C. S. The Silva of North America. Vol. 1, 1891.

Small, J. K. Manual of the Southeastern Flora. 1933.

Weatherby, C. A. A new Magnolia from west Florida. Rhodora 28:35. 1926.

Wilson, E. H. Aristocrats of the Trees. 1930.

New Associates

The Arboretum is happy to welcome the following new Associates who have been enrolled since September, 1961:

Mr. Parker Biery

Dr. George C. Buzby, Jr.

Mr. & Mrs. Wm. L. Chapman, II

Mrs. Kathryn E. Darby

Mr. Christopher Davis

Mrs. James B. Drinker

Mr. and Mrs. Herbert Edwards

Mr. Robert W. Evleth

Mrs. John L. Fearey

Mr. William Logan Fox

Mrs. Milton Laden

Mrs. Paul Lewis

Mrs. William Draper Lewis

Mr. A. Douglas Oliver

Dr. and Mrs. Donald V. Rhoads

Mr. A. C. Serrell

Mrs. Walter Smedley

Dr. Louis Spitz

Mr. and Mrs. John Stump

Mr. Albert M. Suggs

Dr. Robert N. Swartley

Five Fall Fungi

PATRICIA ALLISON

Recognition of the importance of the fungus flora of an aboretum can never be far from the minds of individuals whose concern is the well-being of the woody plants under their care, cultivation and study. Unfortunately, it is most often a harmful activity of a fungus that brings this recognition to the surface. For instance, ordinarily inconspicuous leaf spot fungi may cause sudden epidemics that threaten the safety of certain species of trees. Such are the fungi causing anthracnose of species of *Platanus, Juglans, Acer* and *Quercus*. Then there are those pathogens that must be battled year in and year out to prevent the destruction of valuable host plants. Such a war is waged every year in the rose garden against the fungi causing black spot, powdery mildew and stem cankers, and in the greenhouses where tender cuttings are subject to attack from soil inhabiting fungi. Still other fungi are all about, ready to invade the inner core of any tree or shrub that has had its protective mantle of bark and living wood ruptured by storm or accident.

Nevertheless, there are fungal activities other than parasitism that, if not obviously beneficial, are at least of biological interest. A consideration of some of these other varied aspects of the fungal flora of the Morris Arboretum and its environs has proceeded almost continually since the moment the legacy was dedicated, on June 2, 1933. On that date, honorary degrees were conferred upon three distinguished scholars who had been invited to take part in the ceremonies. One of these men was President Abbott Lawrence Lowell, of Harvard University. Another was Dr. Robert A. Harper, Torrey Professor Emeritus of Botany, Columbia University. The third was Dr. A. H. Reginald Buller, Professor of Botany, University of Manitoba, whose address was entitled "Fungi in their Relations with Trees." A section of his talk dealt with disease, to be sure, but others concerned some interesting features of the fungi that cause decay of leaves and wood. Except that some of these fungi might also cause decay of the nonliving heartwood of standing trees, referred to earlier, and thus be harmful, their digestion of leaves and wood is in the main beneficial, for it rids the earth of waste and helps render wood substances once more available to living organisms. As a matter of fact, this cycle that proceeds from living tree to dead wood and back to living organisms can be very rapid, for the fungus fruiting bodies themselves constitute a major source of nourishment to many woodland creatures. Insects, molluscs, mites and mammals are known to consume them. So we come to the first two of our five fall fungi.

POLYPORUS FRONDOSUS and *P. SULFUREUS*

Even though the resemblance may seem remote, these two species are in the same large taxon as the mushroom we in the United States purchase in the grocery store. Their vegetative structure consists of miles upon miles of slender filaments that ramify in the woody substrate. Their characteristic fruiting bodies first appear on the surface of the wood as large mounds of solid flesh. (Fig. 48) As growth continues, caps or horizontal shelves begin to differentiate until in maturity there is a crowded cluster of them. On the lower surface of each of the caps or

Fig. 48. Young *Polyporus sulfureus*. The mass is about 10 inches long.

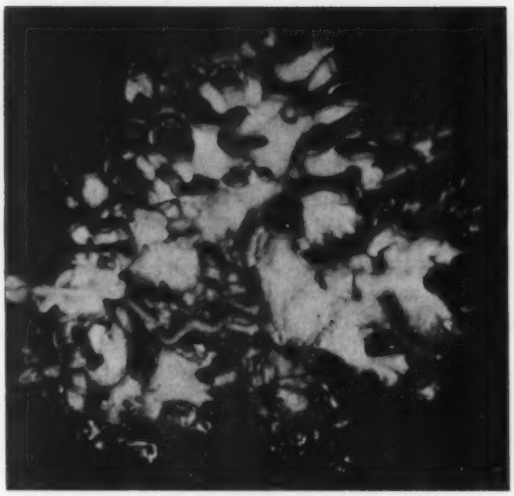

Fig. 49. *Polyporus frondosus.*

shelves is a layer of tiny tubes, whose openings are directed downward. These multitudinous pores give the genus its name. *Polyporus frondosus* is commonly called the Hen of the Woods. It may be that this name was given because of a fancied resemblance of the fruiting bodies to large gray hens crouching in the leaf litter around a massive oak, tupelo or elm. (Fig. 49) It is even possible that some one detected in it the flavor of chicken. In either event, it is an interesting species because of the regularity of its fruiting habits. If the log or tree substrate is large enough, the fungus may be relied upon to appear in large quantities for several years. This year was an especially good one. One tree yielded an estimated 40 pounds of young fruiting masses, enough to satisfy the cravings of every known mycophagist on the staff, and still leave some for classroom study.

The second polypore, *P. sulfureus,* is known as the Sulfur Mushroom because of its color. It is regrettable that Figure 50 cannot show this. The undersides of the shelves are bright yellow; the tops, rich salmon. It grows on stumps and living trees, as does *P. frondosus,* but the fruiting bodies frequently form very high above the ground. A ladder and luck are needed to harvest the heavy clusters that grow from a tall black locust in the Botany Garden on the campus. When the fruiting body is young, the flesh is nothing like that of the corky, tough mature mass. As food, it is despised by some collectors, but others claim to relish the tender young stage. Perhaps the substrate induces variations in flavor, for *P. sulfureus* causes a red-brown heart-rot of trees of a large number of genera. This detrimental activity, together with the beauty and delectability of the fruiting body are enough to make the species noteworthy, but mention should be made of the fact that it was once claimed that the fruiting bodies glowed in the dark! This has never been corroborated, not even by the late Dr. Buller who probably examined more fungi for this characteristic than any other person so far this century. There are a score of fungi that *are* luminescent, however, and some of them "fruited" in great profusion this fall.

Bioluminescence

Most of the organisms that are luminescent live in marine habitats, and some, certain tiny dinoflagellates, can set the seascape aglow in their abundance. Among terrestrial forms there are numerous bacteria, worms and, of course, the fireflies. Some organisms glow because of the bacteria living in or on them. Others secrete luminescent compounds into their environment. The light that is generated by others, however, is released only by shining from the cell interior. Before the age of electricity, many more non-scientists must have been conscious of this weird natural source of light. Not only were their surroundings more dimly lit, but lack of refrigera-

Fig. 50. *Polyporus sulfureus.* Picture taken 3 days after Fig. 48.

Fig. 51. *Clitocybe illudens.*

tion allowed luminescent bacteria to grow on such substrates as fish and meat. Considering the fact that even laboratories were illuminated by candlelight, it is no wonder that natural luminescence intrigued the chemist Robert Boyle to the extent that he tried to learn something of its secrets and became the first, in 1667, to note the dependency of the phenomenon in glowing wood upon something in the air.

Much later, (1885-7) DuBois made water extracts of a luminous mollusc and demonstrated what he called the "luciferin-luciferase" reaction. At first such unheated extracts glowed in the dark, then the light gradually diminished. If a portion of a fresh extract were boiled, then cooled, it would not glow, but if some of the original unheated extract whose light had just gone out were added to the portion that had been boiled, the luminosity returned for a while. DuBois concluded that there was one compound, "luciferin", that was not destroyed by heat, and another, an enzyme, "luciferase," that was destroyed by heating. He suggested that the enzyme promoted the oxidation of luciferin and caused the emission of light. Thus, in the original extract the light went out only when all the luciferin was oxidized. If however, an additional amount of this substrate were supplied in the form of the heated and cooled extract, light once again appeared.

Thanks to continuing research on bacteria, dino-flagellates, crustaceans, millipedes, and fireflies, we now know that the luciferin of one organism is not necessarily the same as that of another. The same may be said for the enzyme luciferase. It is thought also that oxidation of a luciferin compound alone is not sufficient to emit light, but that in the process the oxidized luciferin molecule is brought to an excited state and that it is during the decay from this state that light is emitted. The process is exceedingly effective. *Visible* light can be generated when the luciferin from a small crustacean is so dilute that there is only one part in 10 billion parts of water. The luciferase from the same animal can cause visible light emission from luciferin when it is present in a concentration of one part in 1000 billion parts of water. In the firefly, the light energy yield has been reported as approximately 1 quantum per luciferin molecule.

In certain organisms additional compounds are involved in the process. Furthermore, it is now known that some species are not dependent upon molecular oxygen for light emission, and, indeed, that certain luminescent organisms do not give a positive "luciferin-luciferase" reaction at all. Among the latter are the luminescent fungi. If such a system exists in the fungi, it must be under extremely delicate control within the cells. Buller, for instance, studied a ubiquitous fungus, *Panus stipticus.* The variety that grows in North America is luminescent, but its counterpart in Europe is not. This is a rugged fungus. Its small fruiting bodies commonly form in the fall and are subject to repeated desiccation, yet when remoistened, spore production is renewed, and, more interesting, the luminescent quality, lost in drying, is restored. (The writer has just returned from the darkroom to check the luminescence of some specimens that had earlier been remoistened after having been dry for a month. The usual wait of about ten minutes was necessary to get accustomed to the darkness, then the steady bluish glow was observed!) It was from this relatively indestructible fungus that Buller attempted to obtain a luminescent

Fig. 52. *Clitocybe illudens.* Part of the clump pictured in Fig. 51 photographed by electric light. Distance to camera 16 inches.

Fig. 53. *Clitocybe illudens.* Same as Fig. 52 but photographed by its own light. Exposure 2 hrs; film ASA 3000.

extract. Yet, before his very eyes, the gentle light was extinguished as moist fruiting bodies were squeezed between glass plates.

CLITOCYBE ILLUDENS

Clitocybe illudens, like *Panus,* resembles the grocery store mushroom more closely than do *P. frondosus* and *P. sulfureus,* since the caps have central stems and bear gills, rather than tubes, on their under surfaces. *C. illudens* is far handsomer however. The large fruiting bodies are bright yellow-orange, and grow in splendid clusters on roots and stumps. These spots of color in the slanting illumination of autumn are indeed beautiful, but it may be this very beauty that indirectly leads to sickness among persons of European origin who like to gather and eat mushrooms. *C. illudens,* in color, and slightly in appearance, resembles one of the most delicious comestible wild mushrooms, *Cantharellus cibarius,* that is commonly collected for food in Europe. The sudden sight of the beautiful Clitocybe must cloud the preception, for in most respects the two species are quite different. *Clitocybe illudens* can cause extremely uncomfortable gastro-intestinal disturbances in certain individuals. It was such an unfortunate report that signalled the advent of the fruiting period of the fungus this fall. At Militia Hill, not far from the Arboretum, it was found in profusion (Fig. 51).

The common name of *C. illudens* is Jack-o-Lantern, and for a good reason. It is one of the most brilliantly luminescent mushrooms. It can be understood, then, that the first place the collection went was not the laboratory, but the darkroom. Thanks to the new Polaroid film with a speed of 3000, it was not too difficult to photograph the cluster of fruiting bodies by their own light, revealing clearly the gill structure (Figs. 52 and 53).

Portions of the stems of the mushroom were surface-sterilized, then planted on a sterile nutrient medium. The cultures of vegetative mycelium obtained were observed in the darkroom, and they too emit a bluish glow.

ARMILLARIA MELLEA

Armillaria mellea is another gilled mushroom, and another luminescent one. Whereas the fruiting body of *C. illudens* glows brilliantly, that of *A. mellea* does not; *C. illudens* may cause illness if eaten, *A. mellea* delight. Its common name is the Honey Mushroom, not because of its flavor but because of the color of the caps of some forms of this extremely variable species. In a good season, like this one past, the profusion of fruiting bodies is spectacular. Within an area approximately 15 by 20 feet where brush and logs had been cast grew hundreds upon hundreds of mushrooms. (Fig. 54). The splendor of the sight was diminished by the thought that the trees from which the logs came may have died because of the parasitic activities of this mushroom.

Another name for *A. mellea* is the Shoestring Fungus. The vegetative stage forms thick dark strands resembling shoestrings beneath the bark of affected trees and logs. These rhizomorphs, as they are called, are luminescent, as are the hyphae buried in the wood. The luminescence is so bright that the wood itself seems to glow ("Foxfire"). It may very well have been such wood that Robert Boyle studied, for the species is widely distributed in the world. As a consequence, there are many tales of woodland lore

Fig. 54. *Armillaria mellea.* There are over 50 fruiting bodies in various developmental stages in this picture.

Fig. 55. Normal *Collybia dryophila.*

associated with it. It is said that its powers of illumination may be utilized in marking trails that can be followed in the dark. One recent visitor to the Arboretum recalled camping escapades of his youth, claiming that those boys who hung glowing wood in their tents received more mosquito bites than those who did not! Not a little consternation was caused among modern troops who first witnessed the eery light in woodland camp sites.

Occasionally *A. mellea* forms distorted fruiting bodies that bear little resemblance to normal ones.

COLLYBIA DRYOPHILA

Collybia dryophila is included among our fall quintet, not because it glows, not because it causes sickness of plants or people, but because, as mentioned for *A. mellea,* it can be its own worst enemy. A large collection was made at the Arboretum this fall that included all gradations in severity of distortion (Figs. 55 and 56). A few of the fruiting bodies were normal. Others bore small nodules of pale tissue on the caps, gill edges, or stems. Still others were so tumorous that none of the normal parts of a mushroom could be distinguished. Instead there was mass of contorted whitish flesh connected to the abundant mycelium in the compost substrate. One interesting thing about these masses is that a seemingly normal layer of spore-bearing cells covers them. This led early investigators to believe that another fungus was parasitic upon the Collybia. Now the consensus seems to be that this species of Collybia like certain others, including *Armillaria mellea,* is sometimes unable to differentiate properly. The cause is unknown.

As with *Clitocybe illudens,* cultures were made from this collection of fungi. Spores were allowed to fall from an apparently normal cap onto a sterile culture medium. They germinated, yielding a fungal colony from which subcultures were obtained. A small tumor was surface-sterilized and planted on a similar medium. Subcultures of the resulting colony were also made. To date, although extensive growth has occurred, nothing has been observed that clearly distinguishes the fungal tissue originally obtained from a healthy fruiting body from that obtained from a tumorous mass.

Interesting as the five fungi are in our present state of knowledge, it is clear that there is much opportunity for further investigation.

BIBLIOGRAPHY

Buller, A. H. R. 1924. Researches on Fungi. Vol. III, repr. 1958. Hafner Publ. Co. New York.

Buller, A. H. R. 1933. Fungi in their Relations with Trees. in Proceedings at the Dedication of the Arboretum. Chestnut Hill, Phila., Pa.

Buller, A. H. R. 1934. Researches on Fungi. Vol. VI. repr. 1958. Hafner Publ. Co., New York.

Harvey, E. Newton. 1952. Bioluminescence. Academic Press, N. Y.

Harvey, E. Newton and Bernard L. Strehler. 1956. Bioluminescence in Handbook of Biological Data. ed. William S. Spector. W. B. Saunders Co., Philadelphia.

Haxo, Francis T. and Beatrice M. Sweeney. 1961. "Bioluminescence" in The Encyclopedia of the Biological Sciences ed. Peter Gray. Reinhold Publ. Corp. New York.

Johnson, Frank H., Asamu Shimomura, and Yo Saiga. 1961. Luminescence potency of the Cypridina system. Science. 134: 1755-1756.

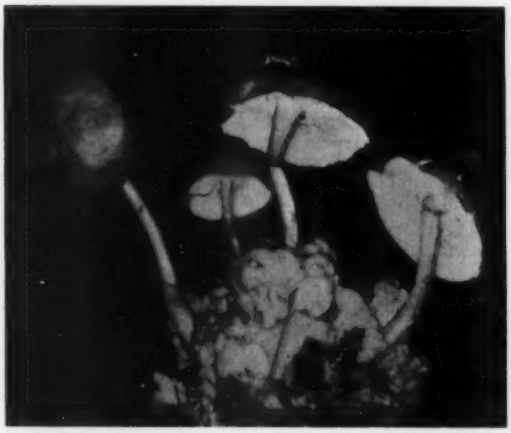

Fig. 56. Large tumorous mass with tumor-bearing fruiting bodies of *Collybia dryophila.*

Library Accessions

Among the items which have been added to the Library during 1961 are the following:

Alkaloid-bearing plants and their contained alkaloids. J. J. Willaman & B. Schubert. U.S.D.A. Technical Bull. No. 1234. Washington. 1961

Aquatic Phycomycetes. F. K. Sparrow. 2nd Edition. Univ. Michigan Press. 1960

*Arizona Flora. T. H. Kearney & R. H. Peebles. Univ. California Press. 1951

Bibliography of Eastern Asiatic Botany. Supplement I. Washington, D.C. 1960

British Cup Fungi and their Allies. R. W. G. Dennis. Bernard Quaritch. London. 1960

Champignons Comestibles et Vénéneux. M. Locquin and B. Cortin. Fernand Nathan, Paris

Encyclopedia of Gardening. N. Taylor. 4th Edition. Haughton Mifflin. 1961

Fern Guide. E. T. Wherry. Doubleday & Co. Garden City. 1961

Flora of the British Isles. A. R. Clapham, T. G. Tutin & E. F. Warbur. Cambridge Univ. Press. 1958

Forest and Shade Tree Entomology. R. F. Anderson. John Wiley & Sons. 1960

Fruit Key and Twig Key to Trees and Shrubs. W. H. Harlow. Dover Publications. New York. 1959

Geological Evolution of Europe. R. Brinkman. Hafner Publishing Co. New York. 1960

Growth, Development and Pattern. N. J. Berrill. W. H. Freeman & Co. San Francisco & London. 1961

Handbuch der Laubgehölze. Band 1. G. Krüssman. Verlag Paul Parey. Berlin. 1960

Lichen Handbook. M. E. Hale, Jr. Smithsonian Institution. Washington, D. C. 1961

Light and Plant Growth. R. van der Veen and G. Meijer. Macmillan Co. 1959

Mushrooms of the Great Smokies. L. R. Hesler. Univ. Tennessee Press. Knoxville, Tenn. 1960

Nadelgehölze. G. Krüssman. Verlag Paul Parey. Berlin. 1960

Pines of Mexico. G. R. Shaw. Publ. Arnold Arboretum No. 1. 1909. Reprinted 1961

Plant Alkaloids. T. A. Henry. J. & A. Churchill. London. 1949

Plant Community. H. C. Hanson & E. D. Churchill. Reinold Publ. Corp. New York. 1961

Plant Disease Handbook. Revised Edition. Cynthia Westcott. Van Nostrand and Co. New York. 1960

Rhododendrons and Azaleas. C. G. Bowers. Ed. 2. Macmillan Co. 1960

Rhododendron and Camellia Yearbook 1961. No. 15. Royal Hort. Soc. London. 1960

Rhododendrons for your Garden. American Rhododendron Society. Portland, Ore. 1961

Selective Toxicity. A. Albert. John Wiley & Sons. 1960

Southern California Gardens. V. Padilla. Univ. California Press. 1961

Swarthmore Plant Notes. Introductory volume and 4 parts. J. C. Wister. Swarthmore, Pa. 1954

Thesaurus Literaturae Botanicae. G. A. Pritzel. Reprint. Gorlich. Milan. 1961

Trees, Shrubs and Vines. A. T. Viertel. Syracuse Univ. Coll. of Forestry. 1961

Trees, Shrubs and Woody Vines of the Southwest. R. A. Vines. Univ. Texas Press. Austin. 1960

Tropical and Subtropical Agriculture. J. J. Ochse. et al. 2 vols. Macmillan. New York. 1961.

Tropical Planting and Gardening. N. Smiley. Univ. Miami Press. Coral Gables, Fla. 1960

Wildflowers of the Sierra. D. Hubbard. Yosemite Nat. Hist. Assoc. 1960

Woody Plants of Ohio. E. Lucy Braun. Ohio State Univ. Press. Columbus. 1961.

Workbook for Woody Plants. J. W. Hardin. Burgess Publ. Co. Minneapolis. 1960

* Gift of Edgar T. Wherry.

Juvenile Variation In Five Red Oak Species

ERNEST J. SCHREINER AND FRANK S. SANTAMOUR, JR.[1]

The Michaux Quercetum study is a joint project of the Morris Arboretum of the University of Pennsylvania and the Northeastern Forest Experiment Station of the Forest Service, U. S. Department of Agriculture, financed in part by the Michaux Fund of the American Philosophical Society. One of the objectives of this project, as outlined by Schramm and Schreiner (1954), is to provide information on the variation within oak species.

This is a report on the juvenile variation in five red oak species: *Quercus marilandica* Muench., *Q. rubra* L., *Q. velutina* Lam., *Q. coccinea* Muench., and *Q. falcata* Michx. The observations cover germination, 1 year of growth in the seedbed, and 2 years in a transplant nursery at the Morris Arboretum in Philadelphia, Pennsylvania. Previous publications on the Quercetum study and pertinent information regarding collection, planting, measurement, and analysis of the nursery phase are included in a recent report by Santamour and Schreiner (1961) on juvenile variation in five white oak species. This introductory material is not repeated here since it is presumed that readers of this report would also have access to the paper on white oak.

DISCUSSION OF RESULTS

QUERCUS MARILANDICA

Blackjack oak was one of the most variable species tested in the Quercetum study (Table 1).

Germination. The two New Jersey seedlots differed significantly from all the others in germination rate. Average date of initial germination for the New Jersey lots was May 16, as compared to May 4 for the lots from the other four localities; by June 1 germination of the New Jersey lots was only 43 percent completed, as compared to an average of 87 percent for the others. The similarity in performance of the seedlots from Kansas to Texas does not support either clinal or racial variation. The variation shown by the New Jersey seedlots cannot be definitely characterized; it may represent local ecotypic variation.

Height Growth. The differences among individual seedlots in 1-year height was highly significant and, even with statistical limitations imposed by the loss of two plots in the third year, 3-year height showed significant differences. Differences in 1-year height also were highly significant among localities. Application of the Studentized range test (Keuls, 1952) resulted in two distinct groups: Arkansas-Texas and New Jersey-Kansas-Illinois. There is some indication of a trend toward better height growth from north to south.

Autumn Coloration. Only seedlot MQ-057 (Fig. 57) from Kansas proved to be significantly different from the average in fall color. The heavy mortality in the New Jersey seedlots during the second growing season may have obscured their true performance. If the New Jersey progenies are discounted, there is a semblance of a trend toward earlier coloration in the northern than in the southern progenies.

Survival. Survival of blackjack oak after transplanting was among the lowest for northern species: 77 percent as against, for example, 97 percent for *Q. rubra* planted the same year. Although there was considerable variation in first-year survival among the blackjack oak seedlots, the differences were not significant. The transplanting *per se* apparently was not the major cause of the mortality, since the progenies that suffered most continued to decline at an accelerated rate during the next 2 years. At the end of three growing seasons survival ranged from 2.4 to 58.3 percent and the differences among seedlots then were highly significant. Application of the Studentized range test gave the grouping shown in the following tabulation.

Survival of Q. marilandica progenies after 3 growing seasons[1]

Seedlot MQ-	State	Survival: Transformed values	Survival: Actual percentages
016	Texas	50.1	58.3
299	Arkansas	47.3	51.3
057	Kansas	46.6	52.9
227	New Jersey	26.7	21.4
421	Illinois	21.0	11.5
051	Kansas	15.0	10.4
222	New Jersey	7.9	2.4

[1]Values within brackets do not differ significantly.

[1] Geneticist-in-charge and geneticist, respectively, Northeastern Forest Experiment Station, U. S. Forest Service. The forest genetics research is in cooperation with the Morris Arboretum of the University of Pennsylvania.

TABLE 1.—DATA ON QUERCUS MARILANDICA AND Q. RUBRA

State	County	Elev.	Growing season	Seedlot number	Germination[1]		Average height 1-year		Average height 3-year		Autumn color ratings[2] 1		2		3	
		Feet	Days	MQ–	Percent		Centimeters		Centimeters		Percent		Percent		Percent	
QUERCUS MARILANDICA																
1953 Fall sowing					*6/1/54*											
New Jersey	Ocean	6	179	222	35		4.3		14.2		0		100		0	
	"	10	"	227	48	43[3]	8.2	6.3	21.9	18.1	14	11	57	68	29	28
Kansas	Pottawatomie	984	183	051	94		7.7		20.6		12		24		64	
	"	1100	"	057	85	89	13.2	10.5	25.1	22.9	9	9	19	20	72	71
Illinois	Pope	——	192	421		96		10.1		28.4		0		45		55
Arkansas	Ashley	180	227	299		83		19.7		41.1		31		49		20
Texas	Harrison	200	240	016		85		23.8		43.5		23		61		16
QUERCUS RUBRA																
1953 Fall sowing					*6/1/54*											
New Hampshire	Hillsboro	795	131	017	96		29.6		87.7		0		15		85	
	"	560	"	018	90		24.5		102.1		1		38		61	
	"	580	"	019	100	96	19.1	23.8	71.0	84.3	0	1	18	25	82	74
	"	812	"	020	98		21.5		76.5		0		24		76	
New Jersey	Somerset	——	165	221	100		21.8		70.4		0		33		67	
	"	——	"	228	100	100	19.0	20.4	66.8	68.6	0	0	54	50	46	50
Pennsylvania	Delaware	——	209	376	99		18.0		66.6		22		46		32	
	"	——	"	377	94	96	17.0	17.5	66.4	66.5	14	18	50	48	36	34
North Carolina	Haywood	4000	171	209	98		17.8		72.8		0		50		50	
	"	"	"	210	98	97	26.4	24.3	91.1	86.3	0	0	35	29	65	71
	"	4100	"	212	96		28.6		95.0		0		12		88	
Kansas	Pottawatomie	1015	183	052	91		15.8		55.2		0		12		88	
	Riley	1090	171	058	96	93	30.0	22.9	89.2	72.2	0	0	15	13	85	87
Illinois	Madison	——	178	416	89		26.4		97.3		1		30		69	
	Richland	——	185	418	100		28.4		82.4		0		12		88	
	Pope	——	192	426	98	96	19.1	24.6	54.1	75.7	10	4	43	26	47	70
	Hardin	520	192	471	100		24.6		68.9		1		21		78	
1954 Fall sowing					*5/16/55*											
Michigan	Clinton	600	158	365		100		21.5		86.6		0		50		50
Massachusetts	Worcester	840	153	176	94		11.1		50.5		3		9		88	
	"	"	"	177	88	92	11.8	11.5	64.6	57.6	10	7	18	14	72	79
Pennsylvania	Monroe	1900	127	542		75		26.4		49.4		0		50		50
Illinois	——	——	——	545		93		29.3		59.3		0		66		34
West Virginia	Tucker	——	145	557		100		15.5		56.4		6		26		68

[1]Percent of total germination on the dates indicated.

[2]1 = green; 2 = red-, orange-, or yellow-green; 3 = red, brown, or fallen. All seedlings were rated between November 4 and 11, 1955, when the 1953 seedlings were two years old and the 1954 seedlings were one year old.

[3]Figures opposite brackets are averages.

Although in general the southern seedlots had the highest survival, the significant differences between the two progenies from Kansas and between the two from New Jersey are as great as or greater than those between localities. Differences in survival between progenies of two trees from similar sites in the same locality probably represent individual variation.

Dr. Edgar T. Wherry (personal communication) has suggested that soil conditions may play a role in survival. Most oaks normally grow under fairly acid soil conditions, and it is possible that some species possess a differential capacity to survive in the circumneutral soil of the Quercetum nursery. Soil acidity may vary greatly within relatively short distances and seed collections from trees no more than a mile apart may be from quite different sites. However, differences in acidity of the soil supporting the parent trees do not explain the large differences in survival between either the two Kansas progenies or the two from New Jersey. According to information supplied by the seed collectors, the two New Jersey trees were only 45 paces apart and within 100 yards of a *Chamaecyparis* swamp on presumably acid soil; the two Kansas trees were within 500 feet of one another on a thin soil underlain by limestone.

TABLE 2.—DATA ON QUERCUS VELUTINA, Q. COCCINEA AND Q. FALCATA

State	County	Elev.	Growing season	Seedlot number	Germination[1]	Average height 1-year		Average height 3-year		Autumn color ratings[2] 1		2		3	
		Feet	Days	MQ–	Percent	Centimeters		Centimeters		Percent		Percent		Percent	
QUERCUS VELUTINA															
1953 Fall sowing					*6/1/54*										
Minnesota	Goodhue	800	162	117	100	14.0		58.5		0		0		100	
	"	"	"	118	100	100[3] 14.0	14.0	60.8	59.7	0	0	0	0	100	100
Michigan	Clinton	900	158	366	100		13.8		46.1		3		13		84
Virginia	Montgomery	2100	168	107	97		13.9		48.2		3		46		51
Tennessee	Anderson	1200	186	233	98	14.8		51.9		7		52		41	
	"	"	"	234	99	98 19.0	16.9	57.1	54.5	3	5	36	44	61	51
Illinois	Johnson	——	187	379	94		13.6		39.2		6		19		75
	Cumberland	——	173	422	99	16.8		58.4		4		44		52	
	"	——	"	425	96	98 20.3	18.6	54.3	56.4	2	3	49	46	49	51
	Pulaski	——	200	428	99		18.8		47.0		3		29		68
North Carolina	Orange	450	210	372	91		20.1		52.0		4		45		51
Alabama	Jefferson	300	240	290	92	20.4		44.5		19		56		25	
	"	"	"	291	90	91 21.7	21.1	52.9	48.7	8	15	42	51	50	34
1954 Fall sowing					*5/16/55*										
Missouri	Dent	1320	182	472	94	9.2		29.7		15		38		47	
	"	"	"	473	85	90 9.0	9.1	26.5	28.1	7	11	36	37	57	52
Arkansas	Stone	980	215	264	100	10.1		33.6		0		18		82	
	"	"	"	266	97	98 9.0	9.6	35.0	34.8	0	0	29	25	71	75
QUERCUS COCCINEA															
1953 Fall sowing					*6/1/54*										
Virginia	Montgomery	2100	168	108	100		12.2		42.0		4		36		60
Tennessee	Anderson	1050	186	231	99	13.6		37.1		1		35		64	
	"	"	"	232	98	98 16.1	14.9	43.3	40.2	5	3	22	28	73	69
Illinois	Hardin	520	192	469	90	22.4		48.2		7		43		50	
	"	"	"	470	98	96 15.6	19.0	42.7	45.5	7	7	38	39	55	54
Alabama	Jefferson	300	240	289	100	13.2		38.0		2		52		46	
	"	"	"	293	94	96 19.1	16.2	49.4	43.7	4	3	66	61	30	36
QUERCUS FALCATA															
1954 Fall sowing					*6/1/54*										
Virginia	James City	——	205	409	26	11.4		37.1		48		39		13	
	York	90	"	410	43	36 14.9	14.1	33.8	37.6	18	30	73	64	9	6
	"	"	"	412	39	15.9		41.8		26		74		0	
Arkansas	Ashley	180	227	298	45		18.7		35.1		42		45		13
Alabama	Jefferson	300	240	292	24		10.6		33.3		51		38		11

[1]Percent of total germination on the dates indicated

[2]1 = green; 2 = red-, orange-, or yellow-green; 3 = red, brown, or fallen. All seedlings were rated between November 4 and 11, 1955, when the 1953 seedlings were two years old and the 1954 seedlings were one year old.

[3]Figures opposite brackets are averages.

Q. RUBRA

1953 Fall Sowing. The data for northern red oak are given in table 1. Although the entire range of this species was not sampled, the provenances represented vary considerably in latitude, elevation, and length of growing season. Nevertheless, seedling performances were quite uniform.

There were no significant differences among seedlots planted in 1953 in germination rate (average 96 percent), 1-year height (average 23 cm.), 3-year height (average 78 cm.), or survival after 3 growing seasons (average 88 percent). Although the variation in 1-year height growth closely approached significance, the tallest and shortest progenies were from adjacent counties in Kansas with similar elevations and lengths of growing season. There was a highly significant

Fig. 57. *Q. marilandica* (MQ-057) is only 2.5 feet tall, which is about the average for this species.

correlation between 1-year and 3-year height. With respect to growth, the data on these progenies indicate that individual variation is as important as racial variation.

The differences in autumn coloration between the Pennsylvania and the Pope County, Illinois, seedlots and the average of all seedlots were significant at the 1-percent level. Also, when localities were compared, the difference between the Pennsylvania seedlings and the average for all localities was highly significant. No significant correlation occurred between percent of seedlings in class 3 (leaves red, brown, or fallen) and length of growing season of the parent locality.

1954 Fall Sowing. There were no significant differences among seedlots in germination rate (average 94 percent). The low value for Pennsylvania seedlot MQ-542 is associated with poor total germination (4 percent).

Although the analysis of variance showed no significant differences among progenies in height growth at the end of the first growing season, the progeny from Illinois was markedly superior to the others. The lack of statistical significance was the result of two factors: poor germination in progenies MQ-365 (Michigan) and MQ-542 (Pennsylvania) which allowed the rapid growth of one or a few individuals to greatly alter the average, and a large difference between the replicates. Progenies in replicate I averaged 27 cm. in height, whereas those in replicate II averaged 12 cm. When the above-mentioned seedlots (MQ-365 and MQ-542) were removed from the analysis, the difference between the Massachusetts and Illinois progenies was significant.

To interpret the data on 3-year height, it must be noted that the replicates were maintained when the 1-year-old seedlings were transplanted; also, that all the seedlings were bitten off at or near the ground line by rabbits at the end of the second growing season. Thus, the 3-year height data on the 1954 progenies may reflect both inherent vigor and relative ability to recover by sprouting after injury.

The differences among progenies in 3-year height (after sprouting) were not significant even with MQ-365 and MQ-542 removed from the analysis. It is of interest, however, that there was no correlation between 1-year and 3-year heights. Moreover, relative progeny heights in the two replicates were reversed: seedlings in replicate I averaged 54 cm. in height, whereas those in replicate II averaged 68 cm. The reason for this reversal is not known. The lack of correlation between 1-year height and height after sprouting does not agree with observations made on *Q. alba* grown under the same conditions (Santamour and Schreiner, 1961).

Fall coloration of foliage developed more slowly in the Illinois progeny than in the orders. Chi-square tests showed a highly significant difference between coloring of the Illinois plants and the average of all progenies.

Q. VELUTINA

1953 Fall Sowing. The 13 seedlots of black oak sown in the fall of 1953 (table 2) were similar in their seedling performance. No significant differences appeared among seedlots in germination rate (average 96 percent), 1-year height (average 17 cm.), 3-year height (average 52 cm.), or survival after three growing seasons (average 78 percent). The correlation between 1-year and 3-year heights was decidedly nonsignificant. (Fig. 58)

Seedlots from Michigan and Alabama were significantly different from the average of all seedlots in fall color. Michigan seedlots had a larger percentage of seedlings with red or brown leaves and Alabama had more seedlings rated green or red-green. Also, the two Alabama progenies differed significantly from each other. When compared to the average, MQ-291 (with 50 percent class 3 leaves) was not significantly different, but the great difference exhibited by MQ-290 (with only 25 percent class 3 leaves) was sufficient to make the combined locality data significantly different. It is also obvious that the seedlots from Minnesota were different from the average, but the small number of seedlings

in these progenies did not allow statistical recognition of this fact.

There is some indication of a north-south trend in fall coloration; northern progenies tended to color earlier. Length of growing season in the locality of seed origin and percentage of seedlings with red or brown leaves was significantly correlated inversely, that is, long-season progenies had fewer red or brown leaves on any given date.

1954 Fall Sowing. Only two seedlots each from Arkansas and Missouri were sown in 1954. There were no significant differences among seedlots in germination rate (average 93 percent), 1-year height (average 9 cm.), or in height after sprouting in 1957 (average 31 cm.). Although no individual progeny differed significantly from the average of all progenies in fall color, a direct comparison between the two localities showed a highly significant difference. The retarded coloration of the Missouri progenies seemingly cannot be accounted for by climatic factors of the seed source; it may have been caused in part by their slightly later germination. We would again stress our opinion (Santamour and Schreiner, 1961) that fall color determinations on 1-year-old seedlings are of questionable value.

Fig. 58. *Q. velutina* (MQ-372) is now 10 feet tall and growing vigorously.

Fig. 59. *Q. falcata* (MQ-410) has developed this interesting, spreading form.

Q. COCCINEA

Data for the seven seedlots of scarlet oak planted in 1953 are presented in Table 2. There were no significant differences among progenies in germination rate (average 98 percent), 1-year height (average 16 cm.), 3-year height (average 43 cm.), or survival after 3 growing seasons (average 73 percent). There was a significant correlation between 1-year and 3-year height.

The difference in autumn coloration between the seedlots from Alabama and the average of all seedlots was highly significant. Alabama progenies had 64 percent of seedlings with green or red-green leaves while the other seedlots averaged 37 percent for these classes. The number of sources sampled is obviously inadequate to conclude that there is a north-south trend in this character.

Q. FALCATA

Although the range of *Q. falcata* extends as far north as Long Island, it is known as southern red oak. Lack of germination in several northern sources left only three seedlots from Virginia and one each from Arkansas and Alabama for comparison (Table 2). There were no significant differences among seedlots in germination rate (average 36 percent), 1-year-height (average 14 cm.), 3-year height (average 36 cm.), fall color, or survival after three growing seasons (average 41 percent). No conclusions as to the extent and type of variation in this species can be made from this limited sample. (Fig. 59)

Summary and Conclusions

This report covers a study of the variation observed during three growing seasons among 7 single-tree progenies of *Q. marilandica,* 24 of *Q. rubra,* 17 of *Q. velutina,* 7 of *Q. coccinea,* and 5 of *Q. falcata.*

The variables considered in the progeny comparisons included earliness of germination, 1-year and 3-year height, autumn coloration, and survival at various ages. On the basis of these variables, and with due consideration of the exploratory nature of this study and the limited sampling of the species, the authors offer the following conclusions:

1. *Q. marilandica.* This species was extremely variable, but from the few seedlots tested it is impossible to reach any firm conclusions regarding the pattern of variation. There was a north-south trend in earliness of fall coloration, height growth, and possibly in 3-year survival. In survival, the difference between the progenies of the two parent trees from Kansas bridged the gap between northern and southern groups.

2. *Q. rubra and Q. velutina.* In the progenies of these species no pronounced tendencies were observed that would indicate racial variation, except that fall coloration in progenies from localities with longer growing seasons tended to be retarded. There was wide individual variation in the factors effecting growth.

3. *Q. coccinea and Q. falcata.* The few provenances of these species included in the study showed no evidence of racial or ecotypic variation. In *Q. coccinea* there was a highly significant difference in fall coloration between the Alabama progeny and the average of all seedlots, but the data are not sufficient to conclude that there is a north-south trend in his character.

4. The frequent, wide variations between progenies of two parent trees from the same locality emphasize the need for maintaining the identity of individual parent-tree progenies in provenance tests with these red oak species.

5. With the possible exception of *Q. marilandica,* individual tree selection appears to offer more promise than ecotypic or racial selection for genetic improvement of these red oak species.

Acknowledgments

The Michaux Quercetum has been a truly cooperative project since its inception. Personnel of the Morris Arboretum of the University of Pennsylvania, originally supervised by former director, J. R. Schramm, and now under the direction of John M. Fogg, Jr., have been responsible for nearly all the contacts with seed collectors and most of the nursery work. H. L. Li and Mary O. Milton have handled the accession records and herbarium specimens.

The measurement and evaluation phases of the project have been handled by the genetics personnel of the Northeastern Forest Experiment Station, U. S. Forest Service.

Literature Cited

Keuls, M. 1952. The use of the "Studentized range" in connection with an analysis of variance. Euphytica 1:112-122.

Santamour, Frank S., Jr. and Schreiner, Ernst J. 1961. Juvenile variation in five white oak species. Morris Arb. Bull. 12:37-46.

Schramm, J. R. and Schreiner, Ernst J. 1954. The Michaux Quercetum. Morris Arb. Bull. 5:54-57.

Arboretum Activities

(Continued from Page 50)

New Board Member

At a meeting of the Advisory Board of Managers held on October 18, Dr. William C. Steere, Director of the New York Botanical Gardens, was elected to the Board to fill the vacancy created by the death of Mr. John B. Kelly.

A native of Michigan, Dr. Steere did his undergraduate and graduate work at the University of Michigan and taught there until 1950 when he was called to Stanford University. In 1955 he was appointed Dean of the Graduate Division at Stanford.

Dr. Steere's field work has taken him to Alaska, Mexico and South America. He has been Editor of the American Journal of Botany and Director of Systematic Biology of the National Science Foundation. On July 15, 1958, he assumed his duties as Director of the New York Botanical Garden.

Rhododendron Test Garden

The local chapter of the American Rhododendron Society, which holds its monthly meetings here, has recently created a Test Garden Committee with Mr. F. J. Sholomskas as Chairman. This committee is empowered to develop and maintain a Rhododendron Test Garden at the Morris Arboretum.

The Arboretum will make available a piece of ground which was formerly used as a holly and azalea nursery and the committee will prepare the soil, select and plant the Rhododendrons, and spray and fertilize the collections. We hope to publish a full account of this project in a future number of the Bulletin.

Operaton Glasstop

One of the major problems besetting an institution such as ours is the maintenance of the older buildings. Several years ago our very competent builder, Mr. Thomas J. Carney, saved the tropical fern house from oblivion by installing a totally new roof. This summer he performed a similar service for our Number 2 Greenhouse, the roof of which was in a state of serious disrepair to the point of being dangerous.

If one wishes to live dangerously he should remove the roof of his greenhouse in May and face the precarious task of installing a new one before the first killing frost of autumn. In this instance Tom made it with a few days to spare and all of the plants concerned are now safely under glass.

Fall Transplanting

Every December issue of this Bulletin carries an account of the routine autumn task of moving plants from lath-house, cold-frame and nursery to their permanent locations in the Arboretum. This fall the staff has been busier than ever before. First of all, the "tennis-court" nursery had to be vacated to accommodate the Rhododendron Test Garden mentioned above. In the second place, space in the cold-frames was desperately needed for new and younger material. Finally, there was our deep-seated desire to add to existing plantings and to create new ones. Most exciting among the latter has been the final selection of a site for the large and important Witch Hazel Family. Other family groupings which have been appreciably enriched are the Rosaceae, Leguminosae, and Aceraceae.

J. M. F., Jr.

Associates' Corner

The Arboretum's "Climatron"

In the preceding issue of the Bulletin I described my visit to the amazing new Climatron at the Missouri Botanical Garden. Back in Chestnut Hill, I began wondering whether the Morris Arboretum should ever attempt to emulate this achievement, when it suddenly occurred to me that we already had a climatron in miniature — namely the Tropical Fern House.

The Fern House was designed and constructed by Mr. Morris, himself, with his local labor, about 1894, with the objective of assembling as many species and varieties of tropical ferns and selaginellas as possible in the given space, — the whole area is not more than 1200 square feet.

To supply a natural habitat besides the required soils, different levels and variations of moisture were created with walks in between. There is a grotto, more of which anon, a stream feeding small pools with goldfish inhabitants, a rocky mound, under which is a tunnel, and a picturesque bridge over the stream. The walls are constructed of the local Wissahickon gneiss and the glass roof is quite original and ingenious. So much so, that when repairs were needed the several greenhouse firms approached either declined to attempt them or quoted a prohibitive price. These difficult repairs have been skillfully accomplished by our own Tom Carney.

The "sunken glass-topped house" as the Fern House has been called, is heated by pipes running around the walls completely covered by foliage, and aired by an automatic vent control The variations of levels, light and air exposure, and moisture according to the proximity of the little stream and pools, conform basically to the principles employed at the Missouri Climatron. And all this was conceived by one man back in the 1800's!

So much for the description of the building — now as to the contents. Literally every inch of space is occupied by tropical ferns and their cousins, the selaginellas which, over a period of years, have mingled to form a fairyland of delicate colors and textures. Even the water areas contain various species of the Floating or Water Fern, *Ceratopteris thalictroides.*

In the dark grotto which constantly drips moisture, the most interesting fern of all grows prolifically: the Killarney Fern, *Trichomones radicans.* It is one of the Filmy Ferns with fronds only a single cell-layer thick, which cannot stand the least drying out. This makes it extremely difficult to grow in cultivation, although in the wild, it is widely distributed in warm moist situations from Spain to Japan.

The English name "Killarney" derives from a clump growing amid spray drenched rocks by a waterfall in Killarney, Ireland. The grotto in our miniature climatron is completely lined with Killarney and this particular colony is probably the largest and best established of any bo-

tanical garden in the temperate zones. It is so famous that the Morris Arboretum is constantly receiving requests for living material from other gardens and Arboretums throughout the country. The little fern is not only tremendously interesting, but also very beautiful with its dark, wet, green leaves sparkling here and there with reflected light like scattered diamonds.

Everywhere one looks in this tropical world there is beauty and fascination, from Australian Tree Ferns to the tiny Maidenhairs only six inches high, while the walls are thickly covered by the Creeping Fig, *Ficus pumila*, giving one the impression of being in an impenetrable jungle.

I am so glad I went all the way to Missouri to discover what an exceptional treasure we have in our midst. If you have not been to the Tropical Fern House, give yourself a Christmas treat in a Dream World.

MARION W. RIVINUS

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Errata

Page 16, line 9 (r.) for *granaiflora* read *grandiflora*
Page 18, line 19 (r.) for *Myrtaceae* read Myrtaceae
Page 25, line 38 (l.) for *ilicifolia* read *ilicifolius*
Page 27 Transpose Figs. 20 and 21
Page 39, line 22 (l.) for Quercetum read Quercetum
Page 45, line 11 (r.) for *prinus* read *Prinus*
Page 45, line 32 (r.) for *prinus* read *Prinus*

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